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# Panel causality analysis between exchange rates and stock indexes for fragile five*

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**Abstract.** *Having become too dependent on foreign capital inflows to finance their economies can be expressed for the fragile five countries. The purpose of this study is to determine the existence and direction of casual relationship between stock indexes and exchange rates for the fragile five. According to Dumitrescu-Hurlin's panel causality test for fragile five countries, bidirectional Granger causality relation is detected for overall data, except before mortgage crisis term, from exchange rate to stock indexes. Dumitrescu-Hurlin's test and a modified type of sequential panel selection methodology are also conducted for searching the determiners of the casual relationship for each time interval.*

**Keywords:** causality relation, fragile five, exchange rates, stock markets, panel data.

**JEL Classification:** G15, F31, C33.

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## 1. Introduction

The countries that have liberalized their economies and deregulated their financial markets have become more integrated with the world economy since 1980s. This process provided a significant opportunity for some of these countries to improve the level of their development. However, the macroeconomic variables of these countries have become more volatile because of increasing capital flows. Due to these developments, the international capital flows to these countries have been risen sharply. As a result of this, the volatility of exchange rates and degree of the risks involved in investments increased. So that, the more flexible exchange rate regimes and the portfolio diversification issues have become more important in the late 1980s' and 1990s for academics, individual/institutional investors and the policy makers. In this context, lots of studies have focused on to the relationship between the foreign exchange rates (ER) and the stock indexes (SI).

However, there is no previous study observed in the related literature on the relationship between SI and ER for fragile five countries, makes this study original. In 2013, Morgan Stanley declared some emerging markets, namely Brazil, Indonesia, South Africa, India, and Turkey as fragile five. According to Morgan Stanley, these countries have some important problems in common. Firstly, their currencies are under the pressure against the US dollar, and secondly each of these countries has a significant and rising current account deficits that make them more dependent on foreign capital flows. So that, it is important to investigate the evidence of relationship between the ER and SI. The aim of this study is to investigate the relationship between the ER and SI by applying the panel causality analysis for fragile five countries. For this purpose, the daily data of ER and SI of the fragile five countries are obtained and formed in to panel data for the fragile five countries and Dumitrescu and Hurlin (2012)'s panel causality test is applied for the period of January 3, 2002 and March 3, 2016. The post hoc test results of Granger causality via Dumitrescu and Hurlin's test and a modified type of sequential panel selection methodology also conducted for searching the determiners of the casual relationship between ER and SI. Up to mortgage crisis (MC), all analyses repeated also for three terms, before MC, during MC and after MC for investigating the existence and/or direction of the causality relationship.

## 2. Relationship between the exchange rate and stock markets

The economic theory on this relationship suggests two alternative approaches (Granger et al., 2000); "flow" and "stock" oriented approaches. According to the flow oriented or known as traditional approach, the real exchange rate affects the international competitiveness, the general economic activity, the balance of trade position, the macroeconomic variables and consequently the real output of the economy (Dornbusch and Fischer, 1980; Aggarwal, 1981). In other words a depreciation in the value of domestic currency influences the country's external competitiveness and hence its

income, trade balance and economic welfare. To this approach increasing stock returns would be associated with the decreasing value of domestic currency. Decreasing value of domestic currency affects the stock prices of the firms regarding to its indirect influence that increases the earnings, profitability and the current and expected cash flows of the firms.

Stock oriented approach that based on portfolio balance model (Branson et al., 1977; Frankel 1983) suggests that the ER are determined by market mechanism. An expected increase in stock prices attracts the foreign investors and hence the foreign capital flows increase the demand for the country's currency and vice versa. Increasing (decreasing) stock returns will increase (decrease) the domestic wealth and the net demand to the domestic currency and its value (Gavin, 1989). According to this equilibrium, the movements in SI may affect the demand and the value of currencies and the value of ER. Especially during the time of a financial crises, it is more significant to maintain this equilibrium in developing countries because of the sudden changes in the behavior of investors. If they lose their confidence in the economic and political stability, they want to get out of the risky countries. Therefore, the demand to the assets of these countries may decrease as the demand to the foreign currencies may increase rapidly. So that for the countries like that, the capital account dynamics have an important role in determining the ER.

In the academic literature, there are many studies on the relationship between ER and SI, and most of them have focused on developed countries. According to some of these studies (Solnik, 1987; Jorion, 1990; Bernard and Galati, 2000; Nieh and Lee, 2001; Griffin and Stulz, 2001) there may be no evidence of any relation observed between ER and SI, while some of them found unidirectional causality from ER to SI and bi-directional or two-way causality between SI and ER (Aggarwal, 1981; Adler and Dumas, 1984; Ma and Kao, 1990; Roll, 1992; Chow et al., 1997; Doukas et al., 1999; Patro et al., 2002; Grambovas, 2003). There are a few studies about the relations between ER and SI (Fang and Miller 2002; Mishra, 2004; Venkateshwarlu and Tiwari, 2005; Wu, 2005; Aquino, 2005; Narayan and Smyth, 2005; Pekkaya and Bayramoğlu, 2008; Kumar, 2009; Rahman and Uddin, 2009) in developing countries.

Ajayi et al. (1998) examined the relation for advanced and Asian emerging markets, and find that in advanced economies there is a relation from SI to ER. Aggarwal (1981)'s study is an example of unicausality from ER to SI. For the period of 1974-1978 in US, Aggrawal (1981) finds that there is an influence from ER to SI. In other words, there is a positive correlation between ER and SI. There are some studies that have the same results for different countries (Donnelly and Sheey, 1996; Glaum et al., 2000; Abdalla and Murinde, 1997; Granger et al., 2000; Pan et al., 2007).

Another group of studies are concerning the unidirectional relation from SI to ER. Granger et al. (2000) found relation from SI to ER for some Asian countries. Ajayi et al. (1998) find that in emerging economies there is a relation from SI to ER. Some of studies found a bi-directional relation between ER and SI. Tabak (2006) found a relation from SI

to ER and vice versa that based on Granger causality model. According to this study there is a linear relation from SI to ER and a nonlinear relation from ER to SI.

## 3. A panel causality analysis for fragile five

The purpose of this study to determine the existence and direction of casualty relation between ER and SE with taking attention on the periods of MC in 2008. In application, the fragile five countries are selected for the sake of homogeneity and much alike properties of them, and also not have been studied before. The names of the fragile five countries, their SI and their ER with their abbreviations are listed in Table 1. The SI of the fragile five countries for the analysis are selected with respect to the index representation of the countries' stock prices and conversant structure of the index. The ER is taken into account as USD over the currencies of that country. The daily market prices of the fragile five as data, are acquired from finance.yahoo.com (18.03.2016) for SI and www.exchangerate.com (18.03.2016) for ER.

**Table 1.** *Names, abbreviations of fragile five countries, their stock indexes and currencies*

| Countries | Brasilia, Br | Indonesia, Id | South Africa, So | India, In | Turkey, Tr |
|---|---|---|---|---|---|
| Stock Index, SI | BVSP | JKSE | FTSE/JSE | SENSEX | BIST100 |
| Exchange rate (with US $), ER | $/Brazilian Real, BR | $/Indonesian Rupiah, Id | $/South African Rand, SR | $/Indian Rupee, InR | $/Turkish Lira, TL |

After synchronizing the data in terms of time by deleting the other countries' observations of the missing one, logarithmic returns of all over the time series calculated separately. Then, overall five double time series has 3038 daily return observations, from January 3, 2002 to March 1, 2016 (03.01.02-02.03.16).

The stationarity of data set is an important problem for time series and panel data. Depending on the data set structure, many tests can be used to examine the stationary characteristics of the series. In this study, we use Im et al. (2003) and Maddala and Wu (1999) panel unit root test to examine the stationarity characteristics of the data. The results (Table 2) show that both SI and ER are stationary at level. So, we can use the return series in the causality analysis.

**Table 2.** *Panel unit root tests of fragile five series*

| | Maddala and Wu | | Im, Pesaran and Shin | |
|---|---|---|---|---|
| | Intercept | Intercept and Trend | Intercept | Intercept and Trend |
| SI | 414.817 (0.000) | 429.356 (0.000) | -2.9173 (0.000) | -21.5244 (0.000) |
| ER | 456.361 (0.000) | 491.362 (0.000) | -22.3544 (0.000) | -23.3863 (0.000) |

**Note:** Numbers in parentheses show the p- values.

To test the existence and direction of the Granger causality between SI and ER, we employ the panel causality test which introduced by Dumitrescu and Hurlin (2012). They explained that their test statistic is based on the individual Wald statistics of Granger non causality averaged across the cross-section units. Dumitrescu and Hurlin (2012) reveal lots of advantages of their test, and main advantages can be summarized as follows; (1) it is very simple to implement. (2) Monte Carlo simulations show that their panel statistics lead to substantial increase in the power of the Granger non-causality tests even for

samples with very small T and N dimensions. (3) Their test statistics do not require any particular panel estimation. (4) The test can be easily implemented in unbalanced panels and/or panels with different lag order K for each individual. Accordingly, even in the condition of determining the wrong lag length, their test statistics is quite reliable. Dumitrescu and Hurlin test statistic can be computed as following (2012:1459):

$$\tilde{Z}_N^{Hnc} = \frac{\sqrt{N}\left[W_{N,T}^{Hnc} - N^{-1}\sum_{i=1}^{N} E(W_{i,T})\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(\tilde{W}_{i,T})}} = \frac{\sqrt{N}\left[W_{N,T}^{Hnc} - N^{-1}\sum_{i=1}^{N} K_i \cdot \frac{T_i - 2K_i - 1}{T_i - 2K_i - 3}\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} 2K_i \cdot \frac{(T_i - 2K_i - 1)^2 \cdot (T_i - 2K_i - 3)}{(T_i - 2K_i - 3)^2 \cdot (T_i - 2K_i - 5)}}} \quad (1)$$

Where $W_{N,T}^{Hnc} = \frac{\sum_{i=1}^{N} W_{i,T}}{N}$; $W_{i,T}$ denotes the individual Wald statistics for the ith cross-section unit corresponding to the individual test of H0:$B_i$=0, and $T_i$>5+2$K_i$.

We implement Dumitrescu and Hurlin (2012)'s panel Granger causality test for the lags of 1, 2 and 3 in this study. The test results are reported in Table 3 show that there is a bi-directional Granger causality between SI and ER variables for the fragile five.

**Table 3.** *Granger causality relations of Fragile 5 (3038x5 observations, 03.01.02-02-03.16)*

| Lags | ER↛SI | | | SI↛ER | | |
|---|---|---|---|---|---|---|
| | W-Stat. | Zbar-Stat. | Prob. | W-Stat. | Zbar-Stat. | Prob. |
| 1 | 6.7216 | 9.0352 | .0000 | 19.2130 | 28.7629 | .0000 |
| 2 | 9.0977 | 7.9235 | .0000 | 21.4787 | 21.7477 | .0000 |
| 3 | 15.5603 | 11.4471 | .0000 | 23.6810 | 18.8492 | .0000 |

**Note:** Prob. values are calculated from statistics of Dumitrescu and Hurlin's Panel Granger causality test. Symbol of ↛ stands for the causality tests's Null hypothesis of "ER↛SI; ER does not homogeneously cause SI".

In order to determine the reason behind the Granger causality relation, a modified type of sequential panel selection methodology is taken into consideration as a post hoc test. In our study, sequential panel selection methodology which is applied to panel unit root tests by Chortareas and Kapetanios (2009) explained as "a sequence of panel unit tests on a reducing dataset where the reduction is carried out by dropping series for which there is evidence of stationarity", is also inversely adapted to panel causality analysis. First, ordinary Granger causality tests of each paired series are conducted for first three lags, their F statistics and p-values are reported in Table 4. Since Dumitrescu and Hurlin panel causality test are conducted for first three lags and we are searching which countries have the determiner of this relation, ordinary Granger causality tests are conducted for the same lags. Orderly, paired series which has highest F statistics, may have the highest impact on determination of the Granger causality relation of Dumitrescu and Hurlin test. Thus, by orderly dropping the paired series of the country which has highest F statistics until the p-value of Dumitrescu and Hurlin test become statistically nonsignificant at .05 level. Table 5 shows the results of this procedure. According to results in Table 5, among fragile five countries, as Br, So, Tr have Granger causality relation from ER to SI but no significant relation detected in that direction for In. As Br, Id, In have Granger causality relation from SI to ER but no significant relation detected in that direction for So.

**Table 4.** *F statistics (prob. values) of Granger causality relations (03.01.02-02-03.16)*

| Lags | Br, ER↛SI | | Id, ER↛SI | | So, ER↛SI | | In, ER↛SI | | Tr, ER↛SI | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.0672 | (.0438) | 3.0798 | (.0794) | 3.9127 | (.0480) | 2.6896 | (.1011) | 19.8588 | (.0000) |
| 2 | 5.9352 | (.0027) | 1.5978 | (.2025) | 1.9335 | (.1448) | 2.5383 | (.0792) | 1.7395 | (.0000) |
| 3 | 5.7577 | (.0006) | 5.2154 | (.0014) | 3.1293 | (.0247) | 4.5062 | (.0037) | 7.3253 | (.0001) |
| | Br, SI↛ER | | Id, SI↛ER | | So, SI↛ER | | In, SI↛ER | | Tr, SI↛ER | |
| 1 | 57.6556 | (.0000) | 22.3973 | (.0000) | 5.2217 | (.0224) | 9.7748 | (.0018) | 1.0153 | (.3137) |
| 2 | 28.6425 | (.0000) | 15.2013 | (.0000) | 2.5808 | (.0759) | 6.7087 | (.0012) | .5636 | (.5692) |
| 3 | 19.8391 | (.0000) | 13.1474 | (.0000) | 1.7507 | (.1545) | 4.3082 | (.0049) | .4230 | (.7366) |

**Note:** Prob. values are calculated from statistics of ordinary Granger causality test. Symbol of ↛ stands for the causality tests's Null hypothesis of "ER↛SI; ER does not cause SI".

**Table 5.** *Sequential panel selection prob. values (03.01.02-02.03.16)*

| Causality test | | Id, So, In, Tr | Br, Id, So, In | So, In, Tr | So, Tr | So, In | In, Tr | Id, In | Id, Tr |
|---|---|---|---|---|---|---|---|---|---|
| 1 lag, | ER↛SI | .0000 | .0006 | .0000 | .0000 | .0000 | .0216 | .0598 | .0000 |
| 2 lags, | ER↛SI | .0000 | .0000 | .0000 | .0000 | .0000 | .0811 | .1317 | .0000 |
| 3 lags, | ER↛SI | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 |
| 1 lag, | SI↛ER | .0000 | .0000 | .0000 | .0344 | .0000 | .0000 | .0000 | .0000 |
| 2 lags, | SI↛ER | .0000 | .0000 | .0000 | .4196 | .0002 | .0000 | .0000 | .0000 |
| 3 lags, | SI↛ER | .0000 | .0000 | .0140 | .8815 | .0182 | .0005 | .0000 | .0000 |

**Note:** Prob. values are calculated from statistics of Dumitrescu and Hurlin's Panel Granger causality test. No unit root is detected statistically at .01 level according to the panel unit root tests of Im et al. (2003) and Maddala and Wu (1999) for all sub groups.

Taking into consideration of "Mortgage Crises" (MC) which is experienced firstly in USA then expand to almost all over the world, we thought that there may be some variations occur in the existence or/and direction of the Granger causality relations. Göçer (2012) stated the beginning date of MC as 15.09.08 when the bankruptcy of Lehman Brothers that is accepted as one of the great financial intuition in USA/world. The impact of the MC may go on even in the beginning of 2010s, for the fragile five countries we accepted that the main effects of MC are detected form 15.09.08 to beginning of 2010. Therefore, the data is split into three parts in terms of time, namely Before MC (03.01.02-14.09.08), during MC (15.09.08-30.12.09) and after MC (04.01.09-02-03.16). The same analyses carried out for these three set of panel data. Results of panel unit root tests, ordinary Granger causality tests and Dumitrescu and Hurlin test are reported in tables of Appendixes 1-7. The summary of inferred results' are presented in Table 6.

**Table 6.** *Inferences from Dumitrescu and Hurlin causality tests*

| Causality relation | Fragile 5 | Br | Id | So | In | Tr |
|---|---|---|---|---|---|---|
| ER→SI, 03.01.02-02-03.16 | Exists | Exists | | Exists | Not Exists | Exists |
| SI→ER, 03.01.02-02-03.16 | Exists | Exists | Exists | Not Exists | Exists | |
| ER→SI, Before MC | Not Exists | | | | | |
| SI→ER, Before MC | Exists | Exists | Exists | Exists | Not Exists | Not Exists |
| ER→SI, During MC | Exists | Exists | Exists | | Not Exists | Exists |
| SI→ER, During MC | Exists | | Exists | Not Exists | | Not Exists |
| ER→SI, After MC | Exists | | Not Exists | Exists | Not Exists | Exists |
| SI→ER, After MC | Exists | Exists | Exists | Not Exists | | Not Exists |

**Note:** MC is mortgage crises between 15.09.08-30.12.09 (265 observations). General results are inferenced from Dumitrescu and Hurlin's Panel Granger causality tests. Individual results are inferenced from Dumitrescu and Hurlin's Panel Granger causality tests and a type of sequential panel selection strategy. The blanks in the table means that no clear evidence has observed in decisions /inferences for that period/direction.

According to inferences from Dumitrescu and Hurlin causality tests as in Table 6, ER and SI have bidirectional Granger causality relationship except before MC. Before MC, SI does Granger cause of ER but not vice versa. During and after the MC, both variables does Granger cause of each other. This results show that, SI and ER prices may effect each other for fragile five countries. However, before MC, there is no evidence found from the panel data about "ER does Granger cause SI for the fragile five". For Br and Id, this interaction is more powerful than the So, In and Tr. For So and Tr, the direction of this Granger causally relation is usually from ER to SI and not vice versa. Different Granger cause feature is realized for In, results that there is almost no durable causality is detected for In, among the fragile five countries.

## 4. Conclusion

The purpose of this study is to determine the existence and direction of casualty relation of the variances between SI and ER for the fragile five countries. According to Dumitrescu and Hurlin's panel causality tests, bi-directional Granger causality relation is observed between ER and SI.

The results obtained from this study are consistent with the theory. They show that there are unidirectional and bi-directional causalities from ER to SI and vice versa for all countries in general. However, considering the different periods the results may vary. For fragile five countries there is no causality observed from ER to SI before mortgage crises. This is a period of rapid growth for the world economy, especially for developing countries. In this period most of the firms used their profits for new investments with the idea that growth process will continue, and the dividend payout ratios are affected from this. Decreasing dividend payout ratios, the long term expected returns from the new investments and increasing interests in real estates may reduce the preferences for stocks. As a result of these, many of investors may decrease the ratio of the stock assets in their portfolios, then from the beginning of mortgage crises, market revised to its ordinary conditions which exist bidirectional causality.

During the Mortgage Crises, while there is a bi-directional causality between ER and SI for Indonesia, there are unidirectional causality from ER to SI for Turkey and Brazil, and causality from SI to ER for Indonesia. After the period of mortgage crises, there are unidirectional causalities from ER to SI for South Africa and Turkey and from SI to ER for Brazil and Indonesia.

The results are similar for the same periods for some countries which can be classified together, for example Turkey and South Africa, Brazil and Indonesia. However, India is distinguished from these countries and seems to be in a different structure. There may be several opportunities for researchers to investigate and for investors to get more and attractive profits according to the causality relations between ER and SI. Also these results are an indicator for policy makers to decide the fiscal and economic policies and the regulations for financial markets. Additionally, the Morgan Stanley's suggestions

argued for exchange rates and deficit may be true for the fragile five countries, but it cannot be said that all of the fragile five countries have similar characteristics in terms of the relationship between exchange rates and stock markets.

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**Appendix 1.** *Panel unit root tests of Fragile 5 for intercepts*

| | | Before MC | | During MC | | After MC | |
|---|---|---|---|---|---|---|---|
| | | 03.01.02-14.09.08 | | 15.09.08-30.12.09 | | 04.01.09-02-03.16 | |
| | | Statistic | Prob. | Statistic | Prob. | Statistic | Prob. |
| SI | Im, Pesaran and Shin W | -17.9301 | .0000 | -6.79616 | .0000 | -19.3552 | .0000 |
| SI | Maddala Wu Chi-square | 325.945 | .0000 | 72.5710 | .0000 | 364.665 | .0000 |
| ER | Im, Pesaran and Shin W | -16.1877 | .0000 | -13.5732 | .0000 | -37.0052 | .0000 |
| ER | Maddala Wu Chi-square | 28.824 | .0000 | 203.705 | .0000 | 529.329 | .0000 |

**Note:** All the panel series of sub groups are researches for unit root tests of Im et al. (2003) and Maddala and Wu (1999). Results of these unit root tests are not reported since there is no unit root detected in .99 confidence level.

**Appendix 2.** *F statistics (prob. values) of Granger causality relations (1435 observations, 03.01.02-14.09.08)*

| Lags | Br, ER↛SI | | Id, ER↛SI | | So, ER↛SI | | In, ER↛SI | | Tr, ER↛SI | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.1689 | (.2798) | 2.6816 | (.1017) | 1.2862 | (.2569) | 4.2988 | (.0383) | .1969 | (.6573) |
| 2 | .9514 | (.3864) | 1.6952 | (.1839) | .6807 | (.5064) | 4.1428 | (.0161) | .1360 | (.8728) |
| 3 | 2.3953 | (.0667) | 1.5684 | (.1952) | .7684 | (.5117) | 2.9444 | (.0319) | .1202 | (.9483) |
| | Br, SI↛ER | | Id, SI↛ER | | So, SI↛ER | | In, SI↛ER | | Tr, SI↛ER | |
| 1 | 52.4084 | (.0000) | 3.5471 | (.0599) | 3.6602 | (.0559) | 1.9432 | (.1635) | 3.4562 | (.0632) |
| 2 | 27.8021 | (.0000) | 2.9668 | (.0518) | 2.4270 | (.0887) | .9674 | (.3803) | 1.9730 | (.1394) |
| 3 | 18.5727 | (.0000) | 3.5574 | (.0139) | 1.7503 | (.1548) | .8301 | (.4773) | 1.3284 | (.2635) |

**Appendix 3.** *Sequential panel selection prob. values (Before MC, 15.09.08-30.12.09)*

| Causality test | | Fragile 5 | Id, So, In, Tr | Br, Id, So, Tr | In, So, Tr | Id, So, Tr | So, Tr | Id, So |
|---|---|---|---|---|---|---|---|---|
| 1 lag, | ER↛SI | .1445 | .1159 | .6395 | .2580 | .7955 | .6365 | .3270 |
| 2 lags, | ER↛SI | .2464 | .1866 | .7868 | .2603 | .4029 | .7768 | .7925 |
| 3 lags, | ER↛SI | .1277 | .3942 | .6053 | .5591 | .3361 | .6997 | .7731 |
| 1 lag, | SI↛ER | .0000 | .0024 | .0000 | .0137 | .0108 | .0018 | .0094 |
| 2 lags, | SI↛ER | .0000 | .0309 | .0000 | .1736 | .0910 | .0120 | .0168 |
| 3 lags, | SI↛ER | .0000 | .0346 | .0000 | .5237 | .3530 | .0105 | .0043 |

**Note:** Prob. values are calculated from statistics of Dumitrescu and Hurlin's Panel Granger causality test.

**Appendix 4.** *F statistics (prob. values) of Granger causality relations (265 observations, 15.09.08-30.12.09)*

| Lags | Br, ER↛SI | | Id, ER↛SI | | So, ER↛SI | | In, ER↛SI | | Tr, ER↛SI | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.2045 | (.0134) | 6.2658 | (.0129) | 3.6562 | (.0570) | .4618 | (.4974) | 15.4264 | (.0001) |
| 2 | 4.4349 | (.0128) | 3.4308 | (.0338) | 1.8353 | (.1616) | .5074 | (.6027) | 9.0014 | (.0002) |
| 3 | 3.8526 | (.0101) | 3.4525 | (.0172) | 3.3755 | (.0190) | 2.0870 | (.1024) | 6.9672 | (.0002) |
| | Br, SI↛ER | | Id, SI↛ER | | So, SI↛ER | | In, SI↛ER | | Tr, SI↛ER | |
| 1 | 1.5059 | (.2209) | 9.6373 | (.0021) | 2.3796 | (.1241) | 3.7792 | (.0530) | 1.5846 | (.2092) |
| 2 | 2.3283 | (.0995) | 3.9838 | (.0198) | 1.2097 | (.3000) | 1.8942 | (.1525) | 1.3238 | (.2679) |
| 3 | 2.6379 | (.0501) | 4.0488 | (.0078) | 1.2849 | (.2800) | 1.5053 | (.2136) | .9358 | (.4239) |

**Appendix 5.** *Sequential panel selection prob. values (During MC, 15.09.08-30.12.09)*

| Causality test | | Fragile 5 | Br, So, In, Tr | Br, Id, So, In | So, In, Tr | Id, So, In | Br, So, In | Id, In | So, In | In, Tr |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 lag, | ER↛SI | .0000 | .0000 | .0000 | .0000 | .0030 | .0033 | .0201 | .2997 | .0000 |
| 2 lags, | ER↛SI | .0000 | .0000 | .0024 | .0000 | .1180 | .0328 | .1807 | .8199 | .0000 |
| 3 lags, | ER↛SI | .0000 | .0000 | .0000 | .0000 | .0000 | .0000 | .0027 | .0034 | .0000 |
| 1 lag, | SI↛ER | .0000 | .0687 | .0000 | .0573 | .0000 | .0616 | .0000 | .0410 | .0986 |
| 2 lags, | SI↛ER | .0121 | .1798 | .0080 | .4247 | .0209 | .1709 | .0072 | .4487 | .4025 |
| 3 lags, | SI↛ER | .0038 | .1606 | .0011 | .6257 | .0080 | .0949 | .0026 | .5100 | .7175 |

**Appendix 6.** *F statistics (prob. values) of Granger causality relations (1338 observations, 04.01.09-02.03.16)*

| Lags | Br, ER↛SI | | Id, ER↛SI | | So, ER↛SI | | In, ER↛SI | | Tr, ER↛SI | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1419 | (.1436) | 3.3929 | (.0657) | 6.3265 | (.0120) | 1.2450 | (.2647) | 16.2505 | (.0001) |
| 2 | 2.3548 | (.0953) | 1.6990 | (.1833) | 3.6048 | (.0275) | .6601 | (.5169) | 7.5352 | (.0006) |
| 3 | 2.6562 | (.0471) | 3.4405 | (.0163) | 3.0253 | (.0287) | 1.8710 | (.1326) | 6.0409 | (.0004) |
| | Br, SI↛ER | | Id, SI↛ER | | So, SI↛ER | | In, SI↛ER | | Tr, SI↛ER | |
| 1 | 15.6510 | (.0001) | 3.9171 | (.0480) | .9754 | (.3235) | 3.0163 | (.0827) | 1.0458 | (.3067) |
| 2 | 8.0964 | (.0003) | 7.4872 | (.0006) | 1.4612 | (.2323) | 2.8041 | (.0609) | .8953 | (.4087) |
| 3 | 5.4913 | (.0009) | 4.7556 | (.0027) | 1.0380 | (.3747) | 1.7617 | (.1526) | .6252 | (.5988) |

**Appendix 7.** *Sequential panel selection prob. values (After MC, 04.01.09-02.03.16)*

| Causality test | | Fragile 5 | Br, Id, So, In | Id, So, In, Tr | Br, Id, In | Id, So, In | So, In, Tr | So, In | Id, In | Br, Id |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 lag, | ER↛SI | .0000 | .0013 | .0000 | .1242 | .0012 | .0000 | .0055 | .1889 | .0782 |
| 2 lags, | ER↛SI | .0000 | .0316 | .0000 | .3251 | .0885 | .0000 | .1108 | .0890 | .1482 |
| 3 lags, | ER↛SI | .0000 | .0000 | .0000 | .0005 | .0002 | .0000 | .0091 | .0043 | .0004 |
| 1 lag, | SI↛ER | .0000 | .0000 | .0810 | .0000 | .0458 | .4078 | .3213 | .0139 | .0000 |
| 2 lags, | SI↛ER | .0000 | .0000 | .0000 | .0000 | .0000 | .2146 | .1107 | .0001 | .0000 |
| 3 lags, | SI↛ER | .0000 | .0000 | .0108 | .0000 | .0013 | .7670 | .2887 | .0001 | .0000 |